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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
Forest Insect Laboratory
Coeur d'Alene, Idaho

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Date February 22, 1944 Author Assistant Entomologist

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TITLE

TESTS OF PENETRATING SPRAYS TO CONTROL THE MOUNTAIN
PINE BEETLE IN WESTERN WHITE PINE

1943

SUBJECT—

INDEX NO.—

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Agricultural Research Administration
Forest Insect Laboratory
Coeur d'Alene, Idaho

February 26th, 1944

To: P. C. Craighead, in Charge, Forest Insect Investigations
From: James C. Menden, Box 630, Coeur d'Alene, Idaho
Subject: Penetrating Sprays

I am enclosing a copy of a report by Mr. Gibson, "Tests of Penetrating Sprays to Control the Mountain Pine Beetle in Western White Pine". This report covers work conducted in the spring of 1944 to test the effectiveness of water emulsions as a carrier for orthodichlorobenzene in lieu of the fuel oils previously used with success.

Your comments concerning the results obtained from these tests will be appreciated.

cc: Parker
Keen
Furniss
Wygant

Tests of Penetrating Sprays to Control the Mountain
Pine Beetle in Western White Pine
1943

Introduction

A long series of experiments⁽¹⁾ and some control projects in both lodgepole⁽¹⁾ and western white pine have demonstrated the effectiveness of oil-base orthodichlorobenzene sprays in the control of the mountain pine beetle. However, problems of transport of such large quantities of oil and lethal materials to remote areas on control projects, make it advisable to substitute water as the penetrating or carrying base, if that is possible. Water would usually be available within a short distance of any field operation. If water could be used, the long haul of oil, often necessitating two or three handlings en route, would be replaced by the comparatively short haul of water from the nearest supply to place of use.

Early tests revealed that the bark of trees that are hosts of the mountain pine beetle, is quite resistant to penetration by water. In an effort to overcome this, spreading, or wetting agents, or both, were added to spray ingredients of water, lethal agent and emulsifier. None have given control to compare with that secured from oil-base sprays, even though some contained a much higher concentration of the same lethal agent. Aid of the Division of Insecticide Investigations and of workers in the Division of Forest Insects engaged in similar problems, was sought. Miscible orthodichlorobenzene (ID#84) and wetting agent Granselli IN 181 (70% sodium lauryl sulphate), were prepared and sent to the Coeur d'Alene Station by Robert D. Chisholm of the Morristown, New Jersey Laboratory. This spray was to be applied according to a prearranged plan agreed upon by the Morristown, New Jersey and Coeur d'Alene, Idaho Laboratories. In addition to the preceding materials, the writer selected the most promising emulsion developed from a long series of tests made at the Coeur d'Alene laboratory. It was to be subjected to a similar series of experiments. To serve as a check against any unusual conditions that might arise, oil-base sprays were also used in a series of experiments on similar material.

The Experiments

For each experiment seven adequately infested western white pine logs about three feet long and averaging 13 inches in diameter, were selected. Although the average diameter was as indicated, extreme variations of all logs were from 8 to 21.5 inches, thus covering most of the diameter range and consequent bark thickness variation that may be expected on actual control projects. In order to test the sprays against the various brood stages, the logs were selected so that each set of seven included approximately similar proportions of each stage of brood development.

(1) Grand Teton Park and Wasatch National Forest
(2) Coeur d'Alene National Forest

In treating, each log was sprayed until a surface-saturated condition was attained. This was indicated by the shiny appearance of the logs from the accumulated spray on the bark surface and the imminence of run-off. It was found that to reach such a visual appearance at least 12 percent more emulsion was needed than oil-base spray, for the same amount of surface area. Treatment of these logs was begun June 24 and completed on July 2. After treating, all logs were subjected to shade provided either by trees or by foliage-covered limbs placed on the logs. This was to prevent any solar killing of the brood.

Final examinations of the logs to determine spray effect were made during the last few days of July. Results from oil-base sprays could have been secured by mid-July but emulsions are slower in their lethal effect.

The data shown for each of the experiments gives the living insects by stages of development at the time of the examination. Larvae, pupae, new adults and emergence, as indicated by emergence holes, were all considered as potentially-emerging brood. It is realized that some normal as well as spray-induced mortality could have and probably did occur to the brood stages beneath the unexamined bark. However, data on such mortality causes was not considered essential to the studies and furthermore the time and expense necessary to collect it would have been prohibitive. Because of the practical certainty of some further reduction in surviving insects between time of examination and emergence, the data for all tests may be considered as a conservative estimate of control.

In the following pages the data for each experiment are shown and discussed.

Testing the effectiveness of penetrating sprays against the
mountain pine beetle in western white pine.
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<u>Experiment</u>	<u>Formula</u>	<u>Quantities</u>	<u>Date of treatment</u>
1	Diesel oil Orthodichlorobenzene (1)	4 parts 1 part	6-24-43

<u>Number</u> <u>of</u>	<u>Di-</u> <u>am-</u>	<u>Sq.ft.of</u> <u>bark sur-</u>	<u>Surviving brood</u>	<u>Date</u>	<u>% of</u> <u>Emer-exam-</u>	<u>con-</u>	<u>Remarks</u>
<u>Tree</u>	<u>Log</u>	<u>ter</u>	<u>Lar.</u>	<u>Pup.</u>	<u>N.A.</u>	<u>sed</u>	<u>ined</u>
1	1	21.5	1.0	-	-	-	7-13 100
		.5		-	-	-	7-28 100
2	2	12.0	1.0	-	-	-	7-29 100
2	12	10.0	1.0	1	-	-	" 98.4 Larva sickly
5	4	15.0	5.0	2	-	-	" 99.4 Larva sickly
5	14	11.0	4.0	-	-	-	" 100
5	17	10.2	3.0	-	-	-	" 100
4	1	14.5	1.5	-	-	-	" 100
<hr/>		Totals	17.0	3	-	-	
Averages		13.5				99.7 ⁽²⁾	

Surviving brood averaged .18 insects per square foot of bark surface.
Estimated coverage was 73 square feet of bark surface per gallon of spray.

(1) Abbreviated to orthene in remainder of tables

(2) Based on potential emergence of 63.2 insects per square foot from untreated material.

Treatment with this spray was designed to show any unusual conditions that might influence control. None developed and the excellent results obtained from this spray in previous years, were repeated.

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Experiment	Formula	Quantities	Date of treatment
2	Water	3 quarts	
	Orthene	1 quart	6-24-43
	Phenol	71 c.c.	
	Triethanolamine	71 c.c.	
	Oleic acid	118 c.c.	

Number of Tree	Di- am- eter in inches	Sq.ft. of bark sur- face ex- amined	Surviving brood	Date exam- ined	% of control	Remarks				
1	4	19.3	1.5	8	1	18	-	7-28	71.5	Some sickly larvae and heavy mortality but survival still too high
2	4	11.7	3.0	-	-	1	1	7-29	98.9	
5	9	12.6	3.0	3	3	15	-	"	88.9	Too many survivors
5	18	10.0	4.0	2	-	-	-	"	99.2	
4	8	12.0	2.5	-	-	14	-	"	91.1	
6	2	16.5	2.0	-	1	13	12	"	79.4	Brood about equally numerous on treated and untreated sides
3	6	11.8	1.0	1	-	12	-	7-28	79.4	
Totals		17.0	14	5	73	13				
Averages						13.4				90.2

Surviving brood averaged 6.2 per square foot of bark surface.
Estimated coverage was 64 square feet of bark surface per gallon of spray.

Survival averaged too high in this experiment. Good control in three logs was offset by comparatively high survival in the others.

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Experiment	Formula	Quantities	Date of treatment
3	Water	3.5 quarts	
	Orthone	1 pint	6-29-43
	Phenol	35.5 c.c.	
	Triethanolamine	35.5 c.c.	
	Oleic acid	59 c.c.	

Number of Tree	Di- am- eter in cm.	Sq.ft.of bark sur- face ex- amined	Surviving brood	Date exam- ined	% of control	Remarks				
1	2	20.3	1.5	-	4	26	-	7-28	68.4	Heavy mortality but still too many survivors
2	8	10.9	1.0	2	-	21	1	7-29	62.0	
5	6	13.6	3.0	3	1	3	-	"	96.3	Heavy mortality even in new adult stage but still too many survivors
5	12	11.8	2.0	2	-	18	1	"	83.4	
5	21	8.4	3.5	1	-	8	-	"	95.9	
4	5	12.5	1.0	-	-	19	-	"	69.9	Too many survivors
6	3	16.0	.5	-	20	6	-	"	17.7	
<hr/>		Totals	12.5	8	25	101	2			
Averages		13.4						82.8		

Surviving brood averaged 10.9 insects per square foot of bark surface. Estimated coverage was 69.3 square feet of bark surface per gallon of spray.

Excellent control in two logs was offset by an insufficient amount in four others and very little in the fifth. Control insufficient to be acceptable.

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<u>Experiment</u>	<u>Formula</u>	<u>Quantities</u>	<u>Date of treatment</u>
4	Water	7 quarts	
	Orthene	1 quart	
	Phenol	71 c.c.	
	Triethanolamine	71 c.c.	6-30-43
	Oleic acid	118 c.c.	

Logs given two sprayings with this formula with an intervening period of about 70 minutes between them.

<u>Number of</u>	<u>Di- am- e-</u>	<u>Sq.ft.of bark sur- face ex-</u>	<u>Surviving brood</u>				<u>Date of Emer-exam-con-</u>		
<u>Tree</u>	<u>Log</u>	<u>ter amined</u>	<u>Lar.</u>	<u>Pup.</u>	<u>N.A.</u>	<u>gad</u>	<u>ined</u>	<u>Remarks</u>	
1	8	17.8	3.0	6	-	3	-	7-28 95.3	Larvae sickly. Heavy mortality, much of it recent.
2	6	11.4	1.0	1	-	16	1	7-29 71.5	Too many survivors.
5	10	12.5	3.5	3	1	12	-	" 92.8	Recent mortality but too many survivors.
5	20	8.9	5.0	2	-	4	-	" 98.0	Light brood in log.
4	10	11.4	1.5	-	-	-	-	" 100	Control chiefly in 0-½ larval stages
7	4	16.0	1.5	-	-	-	-	7-28 100	Some larvae had been killed recently.
6	6	15.3	3.0	1	-	3	7	7-29 94.2	Heavy brood
<u>Totals</u>		<u>18.5</u>	<u>13</u>	<u>1</u>	<u>38</u>	<u>8</u>			
<u>Averages</u>								<u>94.9</u>	

Surviving brood averaged 3.2 insects per square foot of bark surface. Estimated coverage was 44.5 square feet of bark surface per gallon of spray for two applications.

Average control with this spray was fairly good but there was too much survival in individual logs. The reason for considerable survival in some, in contrast to excellent control in others, is not apparent.

The double spraying used in this test, would probably raise the cost of treatment to the point where it would be prohibitive.

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<u>Experiment</u>	<u>Formula</u>	<u>Quantities</u>	<u>Date of treatment</u>
5	Diesel oil Orthene	3 quarts $\frac{1}{2}$ quart	6-30-43

<u>Number of logs</u>	<u>Di- am-</u>	<u>Sq.ft.of bark sur-</u>	<u>Surviving brood</u>	<u>Date Exam-</u>	<u>% of control</u>	<u>Remarks</u>
<u>Log</u>	<u>ter</u>	<u>face ex-</u>	<u>Lar. Pup. N.A. fed ined</u>	<u>ined</u>	<u>trial</u>	
1	5	18.8	3.5	4	-	13 - 7-28 91.9 Too much survival in spite of heavy mortality.
2	9	10.6	1.0	3	1	- 7-29 95.3 Larvae sickly.
5	3	15.4	3.0	-	-	" 100
5	22	8.0	2.5	2	-	" 98.7 Survivors sickly.
4	7	12.1	3.0	-	-	" 100 Brood was of 0- $\frac{1}{2}$ larvae.
3	5	12.1	.5	-	-	- 7-28 100 Had been heavy brood.
6	4	15.8	1.0	-	-	- 7-29 100 Some recent mortality of heavy brood.
<u>Totals</u>		<u>14.5</u>	<u>8</u>	<u>1</u>	<u>13</u>	<u>1</u>
<u>Averages</u>						<u>97.5</u>

Surviving brood averaged 1.6 insects per square foot of bark surface. Estimated coverage was 87 square feet of bark surface per gallon of spray.

Average control was excellent with this spray. Considerable survival in one log may have been due to the bark being much thicker than usual, thus decreasing the penetration of the spray.

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<u>Experiment</u>	<u>Formula</u>	<u>Quantities</u>	<u>Date of treatment</u>
6	Water Concentrate (1)	3 quarts 1 quart	7-1-43

<u>Number</u>	<u>Di-</u>	<u>Sq.ft.of</u>	<u>Surviving brood</u>	<u>Date</u>	<u>% of</u>	<u>Remarks</u>
<u>of</u>	<u>am-</u>	<u>bark sur-</u>	<u>Emer-exam-</u>	<u>con-</u>	<u>control</u>	
<u>Tree</u>	<u>Log</u>	<u>ter</u>	<u>Lar.</u>	<u>Pup.</u>	<u>N.A.</u>	<u>gad</u>
1	3	19.8	.5	4	4	20
2	3	11.9	1.0	-	-	-
5	7	13.8	5.0	15	2	18
5	15	10.6	5.0	-	-	-
5	19	9.4	3.5	2	-	-
4	9	11.8	2.5	-	1	4
6	5	15.4	2.5	1	-	5
					15	"
Totals		20.0	22	7	47	15
Averages						92.8

Surviving brood averaged 4.6 insects per square foot of bark surface.
Estimated coverage was 69.3 square feet of bark surface per gallon of spray.
(1) Ingredients and procedure in mixing furnished by the Morristown Forest
Insect Laboratory.

Although the average control was good, in one log it was very poor, possibly because of thick bark, and in two other logs was insufficient to be acceptable.

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<u>Experiment</u>	<u>Formula</u>	<u>Quantities</u>	<u>Date of treatment</u>
7	Water Concentrate	7 quarts 1 quart	7-1-43 Sprayed twice with average time between them of 1½ hours.

<u>Number of</u>	<u>Di- am- e- Tree Log</u>	<u>Sq.ft.of bark sur- face ex- amined</u>	<u>Surviving brood</u>	<u>Date</u>	<u>% of surviv- ing brood</u>	<u>Remarks</u>
			Lar. Pup. N.A. ged ined trol	Amor-exam-con-		
1	6	18.3	1.0	3 - 4 1	7-29 87.2	Heavy brood present when treated.
2	5	11.5	1.0	2 - 6 -	" 87.2	
2	11	10.3	1.0	4 - - -	" 93.6	Surviving larvae small and not developing normally.
5	5	14.3	3.0	1 - 2 -	7-21 98.4	Light brood present when treated.
5	16	10.4	1.25	4 1 8 -	" 83.6	New adults light brown in color.
4	2	13.6	1.5	1 - 13 -	7-29 85.2	Medium brood when treated.
6	8	14.8	1.0	- - 28 -	" 55.7	Heavy brood when treated.
Totals		9.75	15 1 61 1			
Averages		13.3			87.3	

Surviving brood averaged 8.0 insects per square foot of bark surface. Estimated coverage was 45.4 square feet of bark surface per gallon of spray. (1) Ingredients and procedure in mixing furnished by the Morristown Forest Insect Laboratory.

Average control insufficient to be acceptable. Two sprayings would probably be too costly, even if they had given acceptable control.

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<u>Experiment</u>	<u>Formula</u>	<u>Quantities</u>	<u>Date of treatment</u>
8	Water Concentrate (1)	7 quarts 1 quart	7-1-43

Tree Log No.	Diameter at breast height	Sq. ft. of bark surface exposed	Surviving brood			Date of treatment	% of control	Remarks
			Lar.	Pup.	N.A.			
2	10	10.4	1.0	1	-	5	-	7-29 90.5 Heavy brood when treated.
5	11	12.3	3.0	4	1	13	-	" 90.5 Too many survivors.
4	3	13.3	1.0	-	-	26	-	" 58.9
4	6	12.3	1.5	-	-	22	-	" 76.8 Cerambycid larvae alive.
7	3	16.4	1.0	4	1	5	-	7-28 84.2
7	5	15.3	1.5	-	4	12	-	" 83.1
3	2	13.1	1.0	1	-	20	-	" 66.8
Totals			10.0	10	6	103	-	
Averages			13.3				81.3	

Surviving brood averaged 11.9 insects per square foot of bark surface.

Estimated coverage was 56.5 square feet of bark surface per gallon of spray.

(1) Ingrediants and procedure in mixing furnished by the Morristown Forest Insect Laboratory.

Spray ineffective.

Testing the effectiveness of penetrating sprays against the mountain pine beetle in western white pine.

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<u>Experiment</u>	<u>Formula</u>	<u>Quantities</u>					<u>Date of treatment</u>
9	Diesel oil Orthene	13 parts					7-2-43
Sprayed twice with average time between sprayings of 48 minutes.							
<u>Number</u> <u>of</u>	<u>Di- am- eter</u> <u>in mm.</u>	<u>Sq.ft.of bark sur- face ex- posed</u>	<u>Surviving brood</u>	<u>Date</u>	<u>% of exam- ined</u>	<u>Remarks</u>	
<u>Tree</u>	<u>Log</u>	<u>tar</u>	<u>Lar.</u> <u>Pup.</u> <u>N.A.</u>	<u>Emer- ged</u>	<u>con- trol</u>		
7	1	16.5	1.5	11	-	-	7-28 86.3 Surviving larvae all sickly.
3	4	12.4	1.5	-	-	-	" 100 Heavy brood present when treated.
2	7	11.1	1.0	-	-	-	7-29 100
5	2	15.8	1.5	2	-	1	7-21 96.8 Heavy recent mortality of heavy brood.
5	8	13.4	1.5	5	-	1	" 93.7 Heavy recent mortality of heavy brood.
5	13	11.4	4.0	2	-	-	Pupal stage all dead. 7-29 99.2 Heavy recent mortality of heavy brood.
4	4	13.1	1.5	-	-	-	Survivors sickly. " 100
<u>Totals</u>		<u>12.5</u>	<u>20</u>	<u>-</u>	<u>2</u>	<u>-</u>	
<u>Averages</u> 13.4							97.2

Surviving brood averaged 1.0 insect per square foot of bark surface. Estimated coverage was 47.5 square feet of bark surface per gallon of spray.

Excellent control could be expected and did occur in this experiment. However, the double treatment would be too costly compared with equal effectiveness to be secured by one treatment with a more concentrated spray. The additional cost of the latter would be much less than the labor cost necessary for a second treatment with the cheaper spray.

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Experiment

Untreated logs exposed to the same environmental conditions as those which had been treated, to serve as controls or checks for the experiments.

Tree	Log	Di- am- eter	Sq.ft.of bark sur- face ex- amined	<u>Surviving brood</u>				Date exam- ined	Remarks
				Lar.	Pup.	N.A.	ged		
3	1	14.0	.75	2	-	33	2	7-28	
5	1	16.5	.5	2	1	20	1	7-29	
6	1	17.5	.5	5	5	80	1	"	
6	7	15.1	1.0	1	-	36	2	"	
6	10	15.1	.5	2	2	22	-	"	
1	7	18.0	1.0	-	-	40	8	"	
2	1	12.3	.5	1	-	32	2	"	
Totals				4.75	13	8	263	16	

Averages 15.5

Surviving brood averaged 63.2 insects per square foot of bark surface.

The very heavy brood present in one log, while outside of the allowable statistical departure from the average, is typical of the extremes in brood population frequently found in mountain-pine-beetle-infested material. For that reason it is included in the data comprising the average potentially-emerging brood.

Erratic and decidedly less control with water-base sprays, compared with those having an oil base, characterizes results obtained up to the present time at this station, on mountain pine beetle infested material. Superior bark-penetrating qualities seem to account for the greater effectiveness of the oil-base sprays. Furthermore, the Diesel oils used in the oil-base sprays have been found to be more or less toxic without the addition of the lethal agent.

In spite of the superiority of the oil-base sprays up to the present time, the somewhat encouraging results with the 3 to 1 water-base sprays may lead to the belief that further tests should be made with the latter because they seem to offer considerable economy in material and transportation costs. Therefore, an analysis and comparison has been made, based on costs on a control project where a 4 to 1 oil-base spray was used. Only the emulsion developed at the Coeur d'Alene Laboratory has been used in the comparison because it is the only one in which all the ingredients and their cost are known. Lack of detailed data has made it necessary to estimate costs of certain phases of the project. However, as the compared sprays have been placed on a similar basis, any difference between actual and estimated cost would be unlikely to affect the relative position of the sprays. For more ready comparison, costs of the 4 to 1 spray have been placed in the table along with the estimated costs had a 6 to 1 oil-base or a 3 to 1 water-base spray been used. The table follows:

Comparison of costs of sprays per gallon.

Materials	Oil-base		Water-base
	4 to 1 ⁽¹⁾	6 to 1	3 to 1
Diesel oil	.10	.10	none
Orthonone	.95	.95	.95
Emulsifiers, spreading agents, etc.	none	none	.0975 ⁽²⁾
Total cost of materials per gallon of each spray	.27	.2210	.2813
<u>Transportation</u>			
Rail end to road end	.0675	.0675	.0169 ⁽³⁾
Road end to camp	.0550	.0550	.0138 ⁽³⁾
Camp to point of use	.0440	.0440	.0440 ⁽⁴⁾
Total cost to point of use	.4365	.3875	.2585 ⁽⁵⁾ plus 12% equals .3102

- (1) Costs estimated from data for Duchesne Unit of Wasatch National Forest control project in 1940.
- (2) One-half of actual; estimated minimum cost for quantity purchase.
- (3) Based on $\frac{1}{2}$ the amount of the 4 to 1 mixture hauled from rail head to camp.
- (4) Cost of transporting water from source to point of use considered the same as for oil from camp to point of use.
- (5) Based on assumption that 3 to 1 formula would give acceptable control.

From the foregoing tabulation it is seen that a 3 to 1 water-base spray is estimated to be about 18 cents cheaper per gallon than the 4 to 1 oil-base spray actually used and slightly less than 13 cents cheaper than a 6 to 1 spray. However, the water-base spray requires a greater amount of and much more careful mixing, which would raise the labor cost. In addition it has been found that about 12 percent more oil-base spray is required to give a visual appearance of surface saturation than an oil-base spray. This additional amount of spray would raise the cost of the water-base spray to the point where it is about 12.5 cents per gallon cheaper in material cost than the 4 to 1 and nearly 8 cents less costly than the 6 to 1 oil-base spray. Although this analysis and comparison indicates that the water-base spray would be considerably cheaper in material cost than the oil-base sprays, it must be pointed out that the longer time and greater skill necessary to prepare water-base sprays, would considerably reduce and possibly entirely eliminate the advantage in cheaper material by the increase in labor cost.

In summarizing from the preceding comparisons we find that to supplant oil-base sprays now in use, an emulsion must be developed that is as easy to mix as the oil-base spray, has cheaper ingredients, and is as effective in control. Up to the present time two of these goals seem remote, water-base sprays being superior only in cheaper material costs.

Summary and Conclusions

Comparing the results obtained from the emulsion developed at the Coeur d'Alene Laboratory with those from the material sent from Morristown, leaves little to choose between the two. Better results at one concentration for one emulsion were offset by superiority of the other at another concentration. For more ready comparison, a summary of the data from the experiments conducted in 1943, is presented.

Summary of experiments conducted with penetrating sprays
on mountain pine beetle infested western white pine logs.

Coeur d'Alene National Forest

1943

Ratio of carrier to lethal agent	Coeur d'Alene emulsions		Morristown emulsions		Diesel oil-orthene	
	Survivors per sq. ft.	Percent of control	Survivors per sq. ft.	Percent of control	Survivors per sq. ft.	Percent of control
3 to 1	6.2	90.2	4.6	93.8	-	-
6 to 1	-	-	-	-	1.6	97.5
7 to 1	10.9	82.8	11.9	81.2	-	-
7 to 1 (two sprayings)	3.2	94.9	8.0	87.3	-	-
4 to 1	-	-	-	-	.18	99.7
13 to 1 (two sprayings)	-	-	-	-	1.8	97.2
Untreated	63.2					

Inspection of the preceding summary reveals the superiority of the oil-base sprays in control effectiveness.

Earlier tests, as well as those in 1943, have shown no emulsion that will give consistently satisfactory control against the mountain pine beetle in western white pine. For that reason none can be recommended for use on control projects.